J. Clin. Chem. Clin. Biochem.
Vol. 20, 1982, pp. 533–536

The Influence of a 100 km Run on the Composition of HDL

By *H. Schriewer, V. Günnewig, K. Jung*[1]) and *G. Assmann*

Zentrallaboratorium der Medizinischen Einrichtungen der Westfälischen Wilhelms-Universität Münster/Westfalen und Institut für Arteriosklerosеforschung an der Universität Münster
[1]) *Institut für Sportmedizin der Westfälischen Wilhelms-Universität Münster/Westfalen*

(Received March 3/April 30, 1982)

Summary: In 26 male participants in a 100 km run, concentrations of the HDL constituents cholesterol, apolipoprotein A-I, phosphatidyl choline and sphingomyelin were determined before and immediately after the run. Before running, the values for HDL cholesterol were higher in the participants than in a control population. However, the HDL sphingomyelin, HDL phosphatidyl choline and HDL apolipoprotein A-I values for the participants did not differ from the values in a control population. After the 100 km run only the HDL cholesterol values were increased whereas the other HDL constituents were not affected by the run. It is concluded, that the single exposure to prolonged heavy exercise produces a change in HDL composition which is characterized by an exclusive increase in the cholesterol content of the HDL.

Die Beeinflussung der Zusammensetzung der HDL durch einen 100 km-Lauf

Zusammenfassung: Bei 26 männlichen Teilnehmern eines 100 km-Laufes wurden die Konzentrationen der HDL-Bestandteile Cholesterin, Apolipoprotein A-I, Phosphatidylcholin und Sphingomyelin vor und unmittelbar nach dem Lauf bestimmt. Die HDL-Cholesterinwerte der Teilnehmer des 100 km-Laufes waren höher als die entsprechenden Werte eines Kontrollkollektivs, während bei den HDL-Sphingomyelin-, HDL-Phosphatidylcholin- und HDL-Apolipoprotein A-I-Werten zwischen den Teilnehmern des 100 km-Laufes und dem Kontrollkollektiv kein Unterschied bestand. Nach dem 100 km-Lauf waren nur die HDL-Cholesterinwerte erhöht, während die Konzentrationen der anderen HDL-Komponenten durch den Lauf nicht beeinflußt wurden. Die Ergebnisse deuten darauf hin, daß es im Laufe einer hohen körperlichen Belastung zu einer Änderung in der Zusammensetzung der HDL kommt, die durch einen exklusiven Anstieg des Cholesteringehaltes der HDL charakterisiert ist.

Introduction

The analysis of the HDL fraction in blood serum has become increasingly important in recent years as a risk indicator or potential protective factor against coronary heart disease (1–5). The method most widely used to date for quantifying HDL involves the determination of the proportion of cholesterol in HDL following separation of the HDL by ultracentrifugation or precipitation of apolipoprotein B-containing lipoproteins. It has been shown in various investigations that physical activity results in an increase in HDL cholesterol concentration (6, 7, 8). However, the HDL do not represent a single substance, but a heterogeneous group of macromolecules varying in composition, metabolism and physicochemical properties. As a consequence of this heterogeneity it is not readily possible to determine HDL mass from the HDL cholesterol value (or vice versa) or even to determine the HDL composition. Therefore, it is of interest to study the influence of physical activity on other HDL constituents such as HDL phospholipids and HDL apolipoproteins.

The purpose of this study is to report the effect of a 100 km-run on the values for HDL cholesterol, HDL phosphatidyl choline, HDL sphingomyelin and HDL apolipoprotein A-I.

Materials and Methods

The study population consisted of 45 male participants in a 100 km-run from June 12 to 13, 1981 in Biel, Switzerland. The personal data and the condition of their training are shown in table 1. Blood samples were taken between 1.5 h and immediately before and between 30 minutes and immediately after the 100 km run. The participants had eaten approximately 4 h before the race, the last main meal being approximately 9–22 h before the race. During the race the runners drank sugared beverages, ate fruit, biscuits and chocolate as well as hot food. The serum obtained was promptly frozen and preserved at – 20 °C. For comparison, a sample of 45 male company employees of approximately equal age was taken from

0340-076X/82/0020-0533$02.00

Tab. 1. Personal data and condition of training of 45 male participants in a 100 km run from June 12 to 13, 1981 in Biel, Switzerland.

	Age (years)	Height (cm)	Weight (kg)	Training (km/week)	(days/week)
n	45	45	45	43	43
$\bar{x}$	42.6	173.2	69.4	70.1	4.1
SD	13.0	7.0	9.4	46.6	1.8
Min	20	157	47	10	1
Max	68	186	93	200	7

the "Prospective epidemiological study in company employees in Westphalia" (42.7 ± 12.5 years).

Analysis

Analysis of the HDL fractions

The HDL fractions were analyzed in the supernatant following precipitation of apolipoprotein B-containing lipoproteins using phosphotungstic acid/$MgCl_2$ in the Boehringer Mannheim Test (Test-No.: 400 971).

HDL cholesterol was determined enzymatically using the CHOD-PAP method (Boehringer Mannheim, Test combination No.: 187 313).

The determination of HDL phosphatidyl choline (9) and HDL sphingomyelin (10) has been described previously in detail.

HDL apolipoprotein A-I was measured using kinetic nephelometry, as described previously in detail (11).

Analysis of total protein

The serum levels of total protein were determined with the SMAC Autoanalyzer (Technicon GmbH, Bad Vilbel, (FRG) as described previously (12).

Statistics

Statistical analysis was done using the *Student*'s -t-test for unpaired and paired data. Results were expressed as mean ± standard deviation.

Results

Initial values for HDL lipid fractions and HDL apolipoprotein A-I in 100 km runners

The initial values for HDL cholesterol were significantly higher in the participants in the 100 km run than the corresponding values in the control population of approximately equal in age (tab. 2). The initial values of HDL phosphatidyl choline, HDL sphingomyelin and HDL apolipoprotein A-I for participants in the 100 km run did not differ from the values in the control population.

There was a positive correlation between HDL cholesterol and both HDL phospholipids measured (tab. 3). Furthermore, both lipid fractions of HDL were positively correlated with each other. A positive correlation was also found between HDL apolipoprotein A-I and HDL cholesterol as well as between HDL apolipoprotein A-I and both HDL phospholipids.

Tab. 2. Concentrations of HDL cholesterol, HDL phospholipids and HDL apolipoprotein A-I in the participants before the 100 km run and in company employees (Prospective epidemiological study of company employees in Westphalia). (mean ± S.D.)

	HDL cholesterol (mmol/l)	HDL phosphatidyl choline (mmol/l)	HDL sphingomyelin (mmol/l)	HDL apolipoprotein A-I (g/l)
100 km runners before the run (n = 45)	1.42±0.50[1])	1.13±0.26	0.21±0.05	1.296±0.263
Factory workers (n = 45)	1.18±0.45	1.23±0.40	0.19±0.05	1.388±0.361

Significance [1]) $p < 0.01$

Tab. 3. Table of correlation coefficients of data measured in the participants of a 100 km run before the run (n = 45).

	HDL cholesterol	HDL phosphatidyl choline	HDL sphingomyelin	HDL apolipoprotein A-I
Age	0.13	0.14	0.002	0.18
Body weight (*Broca*)	− 0.26	− 0.19	− 0.32	− 0.12
HDL cholesterol		0.61[1])	0.74[1])	0.61[1])
HDL phosphatidyl choline	0.61[1])		0.53[1])	0.65[1])
HDL sphingomyelin	0.74[1])	0.53[1])		0.48[1])
HDL apolipoprotein A-I	0.61[1])	0.65[1])	0.48[1])	

[1]) $p < 0.001$

Influence of the 100 km run on HDL fractions

Following the 100 km run HDL cholesterol values were significantly higher ($\bar{x}$ = 1.55 mmol/l) than before the run ($\bar{x}$ = 1.41 mmol/l) (tab. 4). The concentrations of HDL apolipoprotein A-I and both phospholipid fractions were not affected by the run.

Influence of the 100 km run on plasma volume

To determine the extent of plasma volume changes resulting from the race, serum total protein was determined before and after the race. There was a slight, but statistically significant increase in the serum total protein after the race ($\bar{x}$ ± SD = 73.9 ± 3.8 g/l) in comparison to

Tab. 4. Concentrations of HDL lipid fractions and HDL apolipoprotein A-I in participants of a 100 km run before and after the run, $\bar{x} \pm SD$, n = 26.

	Before the 100 km run	After the 100 km run
HDL cholesterol	1.41 ±0.28 mmol/l	1.55 ±0.26 mmol/l[1])
HDL phosphatidyl choline	1.22 ±0.21 mmol/l	1.24 ±0.29 mmol/l
HDL sphingomyelin	0.21 ±0.04 mmol/l	0.21 ±0.06 mmol/l
HDL apolipoprotein A-I	1.337±0.232 g/l	1.337±0.315 g/l

[1]) $p < 0.05$

the results obtained before the run (72.0 ± 4.0 g/l) ($p < 0.05$, t-test for paired data).

Discussion

It has been known for a long time that probands who are physically active exhibit a higher HDL cholesterol level than those who have a sedentary lifestyle and who are physically inactive (6–8). Of particular significance here is the fact that especially regular, long-term physical exercise (running, swimming or bicycle riding for 4 × 30 minutes/week) causes an increase in the serum HDL cholesterol level (13). Our results indicate that the well-trained 100 km runners studied also showed distinctly higher HDL cholesterol values in comparison with a control group of equal age consisting of company employees. A possible explanation for the augmenting effect of physical training on the HDL cholesterol level might be relate to the recent findings, according to which well-trained long distance runners have both a higher serum concentration of HDL cholesterol and higher lipoprotein lipase activities in muscle and adipose tissue in comparison with non-athletes (14). However, it has not been proved with absolute certainty to date that physical activity as such, independent of a decrease in body weight, causes an increase in the HDL cholesterol level. It is well known that overweight probands have a lower HDL cholesterol level than those of normal weight (12). It has also been reported that the serum concentration of HDL cholesterol remains constant if there is no loss of weight during the period of endurance training (15).

On the other hand, *Huttunen* et al. (8) found that a 4 month program of endurance training brought about an increase in HDL cholesterol values independent of a reduction in weight. In our studies, the 100 km-runners differed in body weight (– 5.1% according to *Broca*) to a statistically significant degree from the company employees used for comparison (+ 12.6% according to *Broca*). Interestingly also, the 100 km runners studied showed a further increase of HDL cholesterol after the run. This result is in agreement with several studies of 100 km runners in recent years (16), as well as with the observation that participants of a 70 km cross-country ski race showed increased HDL cholesterol values after the race (17).

In contrast to its effect on the HDL cholesterol level the influence of physical exercise on HDL mass or relative composition is largely unknown at present. Studies regarding the change in HDL apolipoprotein A-I due to physical exercise have until now resulted in contradictory results: *Lethonen* et al. (18) observed a distinct increase in serum apolipoprotein A-I values following physical exercise, while according to the studies by *Huttunen* et al. there was no change in serum apolipoprotein A-I level following several weeks of physical training (8). The 100 km runners studied by us also showed no difference in HDL apolipoprotein A-I values in comparison with the control population.

Until now the effect of endurance training on HDL phospholipids has not yet been investigated. In our study we found no differences of the HDL phosphatidyl choline and HDL sphingomyelin values between the 100 km runners and the control population. Evidently, the 100 km runners exhibit a greater cholesterol to phospholipid ratio and a greater cholesterol to apolipoprotein A-I ratio in their HDL than the untrained subjects studied. In contrast to the increased HDL cholesterol level observed in the runners after finishing the race neither the phospholipid fractions measured nor the HDL apolipoprotein A-I values were affected by the 100 km run. Thus, in the well-trained runners studied after the prolonged exercise, a selective change in HDL composition occurs which is characterized by a further increase in the cholesterol moiety of the HDL. The metabolic origin of our observation deserves further investigation.

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Professor Dr. H. Schriewer
Zentrallaboratorium der
Medizinischen Einrichtungen der
Westfälischen Wilhelms-Universität
Domagkstraße 3
D-4400 Münster/Westf.